PATENT SPECIFICATION (11) 1 542 541

(21) Application No. 10442/77 (22) Filed 11 March 1977 (19)
(31) Convention Application No. 2 611 676
(32) Filed 19 March 1976 in
(33) Fed. Rep. of Germany (DE)
(44) Complete Specification published 21 March 1979
(51) INT. CL.² E21B 1/06
(52) Index at acceptance
E1F 31A 31B 31C 31D1

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(54) METHOD AND APPARATUS FOR SINKING BOREHOLES

(71) I, PAUL SCHMIDT, a German citizen, of Reinherstrasse, 5940 Lennestadt/Saalhausen, West Germany, do hereby declare the invention, for which I pray that a patent may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to methods of and apparatus for sinking boreholes in the ground, for example for ground anchors, soil grouting and injection, well-sinking, or drainage.

For the aforementioned purposes, especially for the installation of ground anchors, it has hitherto been the practice to use a drilling machine for sinking steel tubes into the ground, the leading steel tube being equipped with an annular cutting heat. To drill the borehole, the steel tube is driven by means of a rotating mechanism mounted on the drilling machine. Independently of the rotating mechanism, a string of pipes is operated inside the steel tube with water-flushing, which flushes the spoil drilled by the cutting head out of the top of the sunk casing formed by the tubes. This known method, which is used particularly in ground anchor installation, is extremely expensive, since not only is a heavy and complicated drilling machine equipped with a rotating mechanism and flushing apparatus for the string of flushing pipes required, but also the flushed out spoil which may be soil or rock must be removed from the region of the drilling machine. In addition to this, a powerful water pump is necessary for the flushing.

The aim of the present invention is to provide a method of sinking boreholes for ground anchors or other purposes which is not only simple and convenient to carry out but is also much less expensive than present drilling techniques.

To this end, according to this invention, such a method comprises causing a displacement hammer to move downwards in the ground to displace the ground laterally to form the borehole, pulling a string of follow-up tubes into the borehole behind the hammer as the hammer forms the borehole, the tubes supporting the wall of the borehole, and withdrawing the hammer through the tubes leaving the tubes in place.

The invention also consists in a method of sinking a borehole into the ground, the method comprising operating a pneumatic self-propelled percussion boring hammer, which comprises a tubular housing having a percussion boring tool at its front end and containing a pneumatically-operated percussion mechanism which acts on the tool, to cause the hammer to move downwards in the ground and the tool to displace the ground laterally to form the hole, pulling a string of follow-up tubes into the borehole behind the hammer as the hammer forms the borehole, the tubes supporting the wall of the borehole, and withdrawing the hammer through the tubes leaving the tubes in place.

A preferred device for carrying out the method consists of a self-propelled percussion boring hammer, which comprises a tubular housing having a percussion boring tool at its front end for displacing the ground laterally and containing a pneumatically-operated percussion mechanism which acts on the tool, a widening sleeve provided at the rear end of the housing to effect a second stage of the lateral displacement of the ground, a raially projecting annular flange fixed to the rear end of the housing, an internal annular rebate in the sleeve forming a shoulder against which the flange engages to move the sleeve forward with the housing and means for connecting a follow-up tube to the sleeve, the internal diameter of the sleeve behind the shoulder being such that the housing and the flange can be withdrawn through the sleeve.

Thus, initially a pre-displacement of the soil is carried out by the percussion tool and then a further displacement of the soil is carried out by the succeeding widening sleeve. It is preferred that the widening sleeve be constructed over at least a portion of its length as a cone, in order that the displacement operation shall take place as smoothly as possible.

A seating may be disposed at the rearward end of the widening sleeve. This seating forms the means for the detachable fixing of at least one follow-up tube, having an

external diameter slightly smaller than the diameter of the borehole, that is smaller than the maximum external diameter of the widening sleeve.

The seating can here be formed as a screw thread, by which the follow-up tube, which also, of course then has a screw thread at one end, is screwed on. In this arrangement, the screw thread of the widening sleeve is preferably internal and the adjacent thread of the follow-up tube is external.

Usually, several follow-up tubes are connected together to form a string of tubes. Each follow-up tube is then provided at its end remote from the end having the external thread, with an internal thread for attachment of the next succeeding follow-up tube.

Alternatively the follow-up tube or tubes may be of plastics material and be connected to one another by an adhesive. In this case, the follow-up tubes are fixed together by a sleeve, which preferably surrounds two follow-up tubes at their junction and is fixed to both by the adhesive. This results, firstly in a good connection between adjacent follow-up tubes and secondly in reduced wall friction between the outside surfaces of the follow-up tubes and the borehole. A contribution to this effect arises from the fact that the external diameter of the widening sleeve is preferably slightly greater than the external diameter of the follow-up tubes.

The internal diameter of the follow-up tubes is preferably a little larger than the external diameter of the annular flange. As a result, it is possible in a very simple manner, after the borehole has been formed, for the displacement hammer to be withdrawn from the borehole within the protection of the follow-up tubes. For this purpose, a pulling rope, serving for pulling the displacement hammer out of the borehole, is secured in the annular flange, which may be formed on a cap.

Two examples of methods and of hammers in accordance with the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is an exploded side view of a displacement hammer with a follow-up tube;

Figure 2 is a side view of the displacement hammer with the follow-up tube screwed on, in a borehole;

Figure 3 is a view similar to Figure 2, but showing the hammer partially withdrawn from the borehole;

Figure 4 shows the borehole after withdrawal of the hammer filled with a hardening material, the follow-up tube still being situated in the upper part of the borehole;

Figure 5 shows a second example of a displacement hammer with different follow-up tubes; and,

Figure 6 shows a borehole with the displacement hammer of Figure 5 partially withdrawn within the follow-up tubes.

A pneumatically-operated self-propelled displacement hammer 1 includes a substantially cylindrical housing 2 containing a percussion mechanism and having disposed at its forward end a conical percussion tool 4 having cutting edges 3, a chisel 5 being inserted into this percussion tool. At the rear end of the housing 2 is an annular flange 6. This is disposed on a cap screwed into the housing 2 of the displacement hammer 1. The external diameter of that part of the annular flange 6 which projects out of the housing 2 is greater than the external diameter of the cylindrical housing 2. At its rear end, the housing 2 is surrounded by a partially externally conical widening sleeve 7, which has an annular rebate 8 forming an abutment shoulder 9, which bears against the annular flange 6. The diameter of the annular rebate 8 is slightly greater than the external diameter of the annular flange 6, so that the widening sleeve 7 can be pushed from the front end of the hammer over the housing 2 as far as the rear end of the housing 2, and sufficiently far for the abutment shoulder 9 to come into engagement with the annular flange 6.

At its end remote from the housing 2, the widening sleeve 7 has an internal screw thread 11, into which a follow-up tube 13 having an external thread 12 is screwed. The follow-up tube 13, having a length for example of 2 m, is, in the example of Figures 1 to 4, of steel and possesses, at its end remote from the external thread 12, an internal thread 14 for the connection of further follow-up tubes or a plug 15, which has a bore 16. The external diameter of the widening sleeve 7 is slightly greater than the external diameter of the follow-up tube or tubes 13. The internal diameter of the follow-up tube or tubes 13 is slightly greater than the external diameter of the annular flange 6. In the region of the abutment shoulder 9, there is a sealing ring 10, between the widening sleeve 7 and the housing 2, to prevent the ingress of water.

As can be seen from Figure 2, the external diameter of the follow-up tube 13 is slightly smaller than the diameter of a borehole 17, produced by the displacement hammer 1.

In Figure 2, the displacement hammer 1 is shown in the lower part of the borehole 17. In the annular flange 6, there is a rope pocket 18 for the attachment of a pulling rope 19, which leads to a pulling apparatus, not shown, by means of which the displacement hammer 1, after the borehole 17 has been formed, can be pulled back again to

the ground surface through the follow-up tube 13.

In Figure 3, the displacement hammer 1 is shown in a raised position within the borehole 17 into which it is moved by means of the pulling rope 19 and actuation of the pulling apparatus.

In order to form the borehole 17 by the method of this invention, first of all the widening sleeve 7 is pushed on to the housing 2 of the displacement hammer 1 from the front until its abuts against the annular flange 6. A follow-up tube 13 is screwed into the screw thread 11 of the widening sleeve 7 and then the entire device is set on the ground at the desired location. By operating the displacement hammer 1 by means of compressed air, the hammer then drives itself to the ground and pulls the follow-up tube 13 after it. In this way the borehole 17 is produced, as shown in Figure 2, the pulling rope 19, which is attached to the annular flange 6, following loosely behind. When the desired depth of the borehole 17 has been reached, the pulling rope 19 is tightened by the pulling apparatus, not shown, as illustrated in Figure 3 and thus the displacement hammer 1 is pulled upwards inside the follow-up tube 13. This can be done even more easily if the displacement hammer possesses a reverse control, by means of which it is possible to reverse the direction of its own driving movement.

As shown in Figure 4, the borehole 17 is used for the formation of a ground anchor. For this purpose, the borehole 17 is filled with a hardening material 21, for example concrete. For this purpose, the plug 15, situated at the upper end of the follow-up tube 13, is fitted with a connection pipe 22, which leads to a grout pump, not shown, by which concrete is introduced into the borehole 17. An anchor bar 23 is then inserted into the concrete 21 forming the ground anchor. The follow-up tube 13 can be recovered before or during the grouting, by means of conventional withdrawal equipment.

If the borehole 17 is to serve for the injection of grout into the ground, then the borehole 17 is filled solely with the hardening material, for example cement grout, without the anchor bar being inserted.

In the example illustrated in Figures 5 and 6, two follow-up tubes 13 are connected together. In this case, the follow-up tubes 13 are of plastics material. The use of plastics tubes as follow-up tubes 13 is to be recommended in those cases in which the borehole 17 is to be utilised for well construction or drainage purposes, since in these cases the follow-up tubes do not need to be recovered but remain in the borehole 17. At their junctions 25, the follow-up tubes 13 are fixed to one another by a sleeve 26, which is somewhat larger in its external diameter than the external diameter of the follow-up tubes 13 and is fixed by an adhesive to the tubes. In the displacement hammer 1, furthermore, an annular flange 6 formed as a cap and having a rope pocket 18 for the attachment of the pulling rope 19, is provided. The pulling rope is conducted out of the uppermost follow-up tube 13 and passes through a clamping device 27, which rests in a holding piece 28 in the uppermost follow-up tube 13. As can be seen from Figure 5, the lower end of the follow-up tube 13 which is adjacent the displacement hammer 1 is seated between the annular flange 6 and the widening sleeve 7, which in this case is furnished with a rearwardly extending cylindrical extension 29. The connection between the displacement hammer 1 and the follow-up tube 13 is maintained by the pulling rope 19 being held firmly clamped in the clamping device 27.

Boreholes can be sunk in a very simple manner with the hammer and method in accordance with the invention, without the need for very complicated boring apparatus.

WHAT I CLAIM IS:—

1. A method of sinking a borehole into the ground, the method comprising causing a displacement hammer to move downwards in the ground to displace the ground laterally to form the borehole, pulling a string of follow-up tubes into the borehole behind the hammer as the hammer forms the borehole, the tubes supporting the wall of the borehole, and withdrawing the hammer through the tubes leaving the tubes in place.

2. A method of sinking a borehole into the ground, the method comprising operating a pneumatic self-propelled percussion boring hammer, which comprises a tubular housing having a percussion boring tool at its front end and containing a pneumatically-operated percussion mechanism which acts on the tool, to cause the hammer to move downwards in the ground and the tool to displace the ground laterally to form the hole, pulling a string of follow-up tubes into the borehole behind the hammer as the hammer forms the borehole, the tubes supporting the wall of the borehole, and withdrawing the hammer through the tubes leaving the tubes in place.

3. A method according to claim 1 or claim 2, in which the borehole is filled with a hardening material after withdrawal of the hammer.

4. A self-propelled percussion boring hammer which comprises a tubular housing having a percussion boring tool at its front end and containing a pneumatically-operated percussion mechanism which acts on the tool, when used in a method in accordance with any one of claims 1 to 3.

5. A pneumatic self-propelled percussion boring hammer for use in a method in accordance with claim 1, the hammer comprising a tubular housing having a percussion boring tool at its front end for displacing the ground laterally and containing a pneumatically-operated percussion mechanism which acts on the tool, a widening sleeve provided at the rear end of the housing to effect a second stage of the lateral displacement of the ground, a radially projecting annular flange fixed to the rear end of the housing, an internal annular rebate in the sleeve forming a shoulder against which the flange engages to move the sleeve forward with the housing and means for connecting a follow-up tube to the sleeve, the internal diameter of the sleeve behind the shoulder being such that the housing and the flange can be withdrawn through the sleeve.

6. A hammer according to claim 5, in which the widening sleeve has a conical external surface.

7. A hammer according to claim 5 or claim 6, in which the means for connecting a follow-up tube comprises a seating provided in the rear end of the widening sleeve.

8. A hammer according to claim 7, in which the seating is forced as a screw thread for receiving a screw-threaded end of the follow-up tube.

9. A hammer according to claim 8, in which the screw thread of the widening sleeve is internal.

10. A hammer according to any one of claims 7 to 9, in combination with a plurality of follow-up tubes which are connected to each other and the front one of which is connected to the sleeve.

11. A hammer according to claim 10, in which the follow-up tubes are of plastics material and are connected to each other by connecting sleeves fixed to the tubes with adhesive.

12. A hammer according to claim 11, in which the connecting sleeves surround the follow-up tubes.

13. A hammer according to any one of claims 10 to 12, in which the external diameter of the widening sleeve is larger than the external diameter of the follow-up tubes.

14. A hammer according to any one of claims 10 to 13, in which the internal diameter of the follow-up tubes is larger than the external diameter of the annular flange.

15. A hammer according to any one of claims 5 to 14, in which the annular flange is disposed on a cap which is screwed into the rear end of the housing.

16. A hammer according to claim 15, in which the cap has a pocket for receiving a rope attachment.

17. A hammer according to claim 16, in combination with a rope attached to the cap, the rope passing through a clamping device at the rear end of one of the follow-up tubes.

18. A hammer according to any one of claims 10 to 17, in which a plug is screwed into the rear end of a follow-up tube.

19. A hammer according to claim 18, in which the plug has a pipe for the injection of grout connected to it.

20. A method according to claim 2, substantially as described with reference to Figures 1 to 4 or Figures 5 and 6 of the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1979
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

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Sheet 1

FIG.1

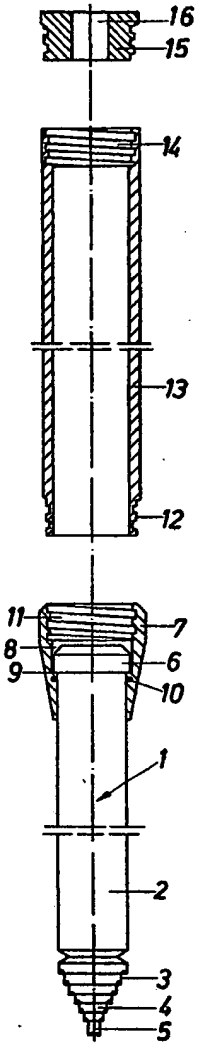


FIG.2

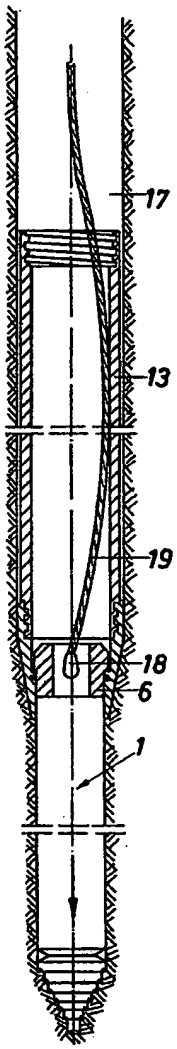


FIG.3

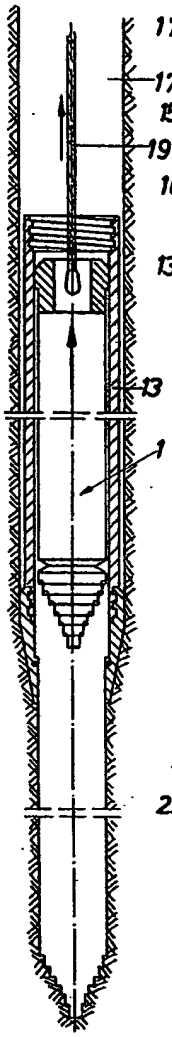
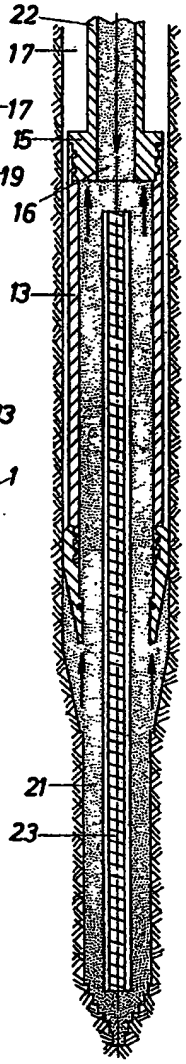


FIG.4



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Sheet 2

FIG.5

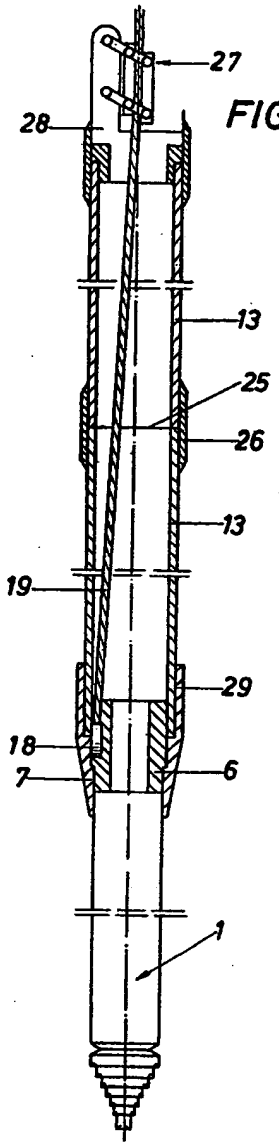

FIG.6